Atmospheric impacts of the 2010 Russian wildfires: Integrating modelling and measurements of an extreme air pollution episode in the Moscow region

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Year: 2011
Journal: Atmospheric Chemistry and Physics. 11 (19): 10031-10056

Abstract:

Numerous wildfires provoked by an unprecedented intensive heat wave caused continuous episodes of extreme air pollution in several Russian cities and densely populated regions, including the Moscow region. This paper analyzes the evolution of the surface concentrations of CO, PM10 and ozone over the Moscow region during the 2010 heat wave by integrating available ground based and satellite measurements with results of a mesoscale model. The CHIMERE chemistry transport model is used and modified to include the wildfire emissions of primary pollutants and the shielding effect of smoke aerosols on photolysis. The wildfire emissions are derived from satellite measurements of the fire radiative power and are optimized by assimilating data of ground measurements of carbon monoxide (CO) and particulate matter (PM10) into the model. It is demonstrated that the optimized simulations reproduce independent observations, which were withheld during the optimisation procedure, quite adequately (specifically, the correlation coefficient of daily time series of CO and PM10 exceeds 0.8) and that inclusion of the fire emissions into the model significantly improves its performance. The model results show that wildfires are the principal factor causing the observed air pollution episode associated with the extremely high levels of daily mean CO and PM10 concentrations (up to 10 mg m−3 and 700 μg m−3 in the averages over available monitoring sites, respectively), although accumulation of anthropogenic pollution was also favoured by a stagnant meteorological situation. Indeed, ozone concentrations were simulated to be episodically very large (>400 μg m−3) even when fire emissions were omitted in the model. It was found that fire emissions increased ozone production by providing precursors for ozone formation (mainly VOC), but also inhibited the photochemistry by absorbing and scattering solar radiation. In contrast, diagnostic model runs indicate that ozone concentrations could reach very high values even without fire emissions which provide "fuel" for ozone formation, but, at the same time, inhibit it as a result of absorption and scattering of solar radiation by smoke aerosols. A comparison of MOPITT CO measurements and corresponding simulations indicates that the observed episodes of extreme air pollution in Moscow were only a part of a very strong perturbation of the atmospheric composition, caused by wildfires, over European Russia. It is estimated that 2010 fires in this region emitted ∼10 Tg CO, thus more than 85% of the total annual anthropogenic CO emissions. About 30% of total CO fire emissions in European Russia are identified as emissions from peat fires. © 2011 Author(s).

Source: http://dx.doi.org/10.5194/acp-11-10031-2011

Resource Description

Exposure : ☑

weather or climate related pathway by which climate change affects health

Air Pollution, Extreme Weather Event, Temperature

Air Pollution: Particulate Matter, Other Air Pollution

Air Pollution (other): CO

Extreme Weather Event: Wildfires

Temperature: Extreme Heat

Geographic Feature: ☑

resource focuses on specific type of geography

None or Unspecified, Urban

Geographic Location: ☑

resource focuses on specific location

Non-United States

Non-United States: Europe

European Region/Country: European Country

Other European Country : Russia

Health Impact: ☑

specification of health effect or disease related to climate change exposure

Health Outcome Unspecified

Mitigation/Adaptation: ☑

mitigation or adaptation strategy is a focus of resource

Mitigation

Model/Methodology: ☑

type of model used or methodology development is a focus of resource

Computing System, Methodology

Resource Type: ☑

format or standard characteristic of resource

Research Article

Timescale: ☑

time period studied

Time Scale Unspecified